

CLAIMS

WHAT IS CLAIMED IS:

1. A method for the manufacture of a three-dimensional object having a desired shape,
5 comprising the steps of:
 - a). forming a mixture that contains a binder and at least one of aluminum or a first aluminum-base alloy into a green composite having said desired shape;
 - b). removing said binder from said green composite by a process effective to maintain said desired shape as a porous preform structure;
 - 10 c). converting a portion of said aluminum to aluminum nitride thereby transforming said green composite to a rigid skeleton of said desired shape with said porous structure; and
 - d). infiltrating, at a temperature equal to or greater than the melting temperature of said aluminum or first aluminum base alloy, said porous preform structure with an infiltrant that is selected from the group consisting of molten aluminum and a molten second aluminum-
15 base alloy to form said three-dimensional object with a near theoretical density.
2. The method of claim 1 wherein said first aluminum base alloy is selected to be an alloy with copper, magnesium, silicon, zinc, titanium, chromium, zirconium, nickel, iron, manganese, or silver, and mixtures thereof.
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3. The method of claim 2 wherein said first aluminum base alloy is alloyed with silicon and magnesium.
4. The method of claim 1 wherein said binder is selected to be a polymer that substantially
25 decomposes to gases at a temperature of between about 300°C and about 500°C in a nitrogen-base atmosphere.
5. The method of claim 4 wherein said first aluminum base alloy is mixed with a nitride control agent.
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6. The method of claim 5 wherein said nitride control agent is selected from the group consisting of tin, lead, bismuth and indium.

7. The method of claim 6 wherein said nitride control agent is present in an amount of from 0.1% to 1.0%, by weight.

8. The method of claim 6 wherein said binder is selected to be a nylon.

9. The method of claim 1 including an addition of an oxygen scavenger to said mixture.

10. The method of claim 9 wherein said oxygen scavenger is selected to be magnesium.

11. The method of claim 10 wherein said first aluminum base alloy is mixed with a nitride control agent.

12. The method of claim 11 wherein said nitride control agent is selected from the group consisting of tin, lead, bismuth and indium.

13. The method of claim 12 wherein said nitride control agent is present in an amount of from 0.1% to 1.0%, by weight.

14. The method of claim 11 including the step of forming a nitride skeleton within said porous preform by exposure to nitrogen at low oxygen partial pressure.

15. The method of claim 1 wherein said infiltrant is selected to be aluminum or an alloy of aluminum and copper, magnesium, silicon, zinc, manganese, chromium, titanium, zirconium, iron, silver, lead, tin, bismuth, antimony, strontium, sodium, or nickel and mixtures thereof.

16. The method of claim 15 wherein said infiltrant is selected to include silicon and magnesium.

17. The method of claim 16 wherein said infiltrant is selected to be aluminum alloy AA6061.

18. The method of claim 16 wherein said infiltrant is selected to have a nominal composition, by weight, of less than about 5% magnesium and the balance is aluminum and inevitable impurities.

19. The method of claim 11 wherein step (b) is at a temperature of between about 300°C and about 500°C, step (c) is at a temperature of from about 500°C to about 570°C and step (d) is at a temperature of in excess of about 540°C and equal or greater than the melting or solidus temperature of the first aluminum alloy.

20. The method of claim 19 wherein steps (b) – (d) are in a single oven programmed with temperatures and times effective for each step and steps (b) and (c) are performed in a nitrogen-base atmosphere and step (d) is performed in a noble gas atmosphere.

21. The method of claim 19 wherein prior to step (b), said porous preform structure is surrounded with a porous support structure, said porous support structure selected to include both a ceramic and an oxygen scavenger.

22. The method of claim 21 in which said oxygen scavenger is selected to be magnesium.

23. The method of claim 19 wherein said desired shape is formed by computer aided rapid prototyping.

24. The method of claim 23 wherein said desired shape is formed by selective laser sintering.

25. The method of claim 1 wherein subsequent to step (d), said three-dimensional object is further densified by hot isostatic pressing.

26. The method of claim 1 wherein subsequent to step (d), said three-dimension object is smooth finished.

27. The method of claim 1 wherein subsequent to step (d), said three-dimension object is heat-treated.

28. A method for the manufacture of a three-dimensional object, comprising the steps of:
a). forming a mixture that contains a binder and at least one of aluminum or a first aluminum-base alloy into a green composite;

b). removing said binder from said green composite forming a porous preform structure;

c). transforming a portion of the aluminum and/or first aluminum base alloy into an aluminum nitride compound by reaction with a nitrogen source to form a rigid skeleton; and

d) infiltrating, at a temperature equal to or greater than the melting temperature of said aluminum or first aluminum-base alloy, said porous preform structure with an infiltrant that is molten aluminum or a molten second aluminum base alloy to form said three-dimensional object with near theoretical density.

29. The method of claim 28 wherein said first aluminum base alloy is selected to be an alloy with copper, magnesium, silicon, zinc, titanium, chromium, zirconium, nickel, iron, manganese, or silver, and mixtures thereof.

30. The method of claim 29 wherein said first aluminum base alloy is alloyed with silicon and magnesium.

31. The method of claim 28 wherein said binder is selected to be a polymer that substantially decomposes to gases at a temperature of between about 300°C and about 500°C in a nitrogen-base atmosphere.

32. The method of claim 31 wherein said first aluminum base alloy is mixed with a nitride control agent.

33. The method of claim 32 wherein said nitride control agent is selected from the group consisting of tin, lead, bismuth and indium.

34. The method of claim 33 wherein said nitride control agent is present in an amount of from 0.1% to 1.0%, by weight.

35. The method of claim 33 wherein said binder is selected to be a nylon.

36. The method of claim 28 including an addition of an oxygen scavenger to said mixture.

37. The method of claim 36 wherein said oxygen scavenger is selected to be magnesium.

38. The method of claim 37 wherein said first aluminum base alloy is mixed with a nitride control agent.

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39. The method of claim 38 wherein said nitride control agent is selected from the group consisting of tin, lead, bismuth and indium.

40. The method of claim 39 wherein said nitride control agent is present in an amount of
10 from 0.1% to 1.0%, by weight.

41. The method of claim 38 including the step of forming a nitride skeleton within said porous preform by exposure to nitrogen at low oxygen partial pressure.

15 42. The method of claim 28 wherein said infiltrant is selected to be aluminum or an alloy of aluminum and copper, magnesium, silicon, zinc, manganese, chromium, titanium, zirconium, iron, silver, lead, tin, bismuth, antimony, strontium, sodium, or nickel and mixtures thereof.

43. The method of claim 42 wherein said infiltrant is selected to have a solidus to liquidus
20 melting range of from 6°C to 100°C.

44. The method of claim 43 wherein said infiltrant is selected to include silicon and magnesium.

25 45. The method of claim 43 wherein said infiltrant is selected to have a nominal composition, by weight, of 5% magnesium and the balance is aluminum and inevitable impurities.

46. The method of claim 28 wherein step (b) is at a temperature of between about 300°C
30 and about 500°C, step (c) is at a temperature of from about 500°C to about 570°C and step (d) is at a temperature in excess of about 540°C and equal to or greater than the melting or solidus temperature of the first aluminum alloy.

47. The method of claim 46 wherein steps (b) – (d) are in a single oven programmed with temperatures and times effective for each step and said steps (b) and (c) are performed in a nitrogen-base atmosphere and step (d) is performed in a noble gas atmosphere.

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48. The method of claim 46 wherein prior to step (b), said porous preform structure is surrounded with a porous support structure, said porous support structure selected to include both a ceramic and an oxygen scavenger.

10 49. The method of claim 48 in which said oxygen scavenger is selected to be magnesium.

50. The method of claim 28 wherein said desired shape is formed by computer aided rapid prototyping.

15 51. The method of claim 50 wherein said desired shape is formed by selective laser sintering.

52. The method of claim 28 wherein subsequent to step (d), said three-dimensional object is further densified by hot isostatic pressing.

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53. The method of claim 28 wherein subsequent to step (d), said three-dimension object is smooth finished.

25 54. The method of claim 28 wherein subsequent to step (d), said three-dimension object is heat-treated.

55. The method of claim 20 wherein said noble gas is selected to be argon.

56. The method of claim 47 wherein said noble gas is selected to be argon.

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